A REVIEW OF THE PHENOLOGY OF *EUPITHECIA TRIPUNCTARIA* HERRICH-SCHÄFFER, THE WHITE-SPOTTED PUG (LEP.: GEOMETRIDAE)

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Introduction

IN A recent article in this journal West (1989) discussed the evidence for bivoltinism in *Eupithecia tripunctaria* H.-S. Two distinct emergences were evident from analysis of the catches made at mercury vapour light at Dartford, Kent, in 1983, 1985 and 1988 and these observations were stated to be confirmed by Peet (1965) and Agassiz (1977) in Co. Cork; Bradley & Pelham-Clinton (1967) in Co. Clare; Evans & Evans (1973) in Surrey and Chalmers-Hunt (1981) in Kent. In the intervening years of 1984, 1986 and 1987 an apparent second emergence was represented in the catches, though the usual first emergence was absent. It is also stated that in Kent the second brood appears to be generally stronger than the first and records cited by Emmet (1989) suggest that this is also the case in Essex. West (1989) still doubts the significance of this evidence and suggests that positive proof of bivoltinism in this species would be found in adults which emerged as a second generation from larvae collected in early summer.

Against this background of uncertainty concerning the phenology of this species, the present authors are able to supply evidence of partial bivoltinism in *E. tripunctaria* in the form of first-hand experience and documented cases of captive second brood emergence and the regular capture of both broods in Rothamsted Insect Survey light traps throughout Great Britain. Before presenting these data it is considered desirable to give a full account of historical opinion on this matter as West (1989) omitted several important references.

Review of suspected bivoltinism

West (1989) states that much of what is written in the 20th century British literature concerning Lepidoptera can be traced back to Barrett (1907). However, in the case of the *Eupitheciini* this is not the case. Most of the important studies on the biology of this group in Britain were done between 1859 and 1874 by Rev. H. Harpur-Crewe. Newman (1869) accredited much of his text concerning the early stages of the pugs to Harpur-Crewe and doubtless these observations were repeated by many subsequent authors without due acknowledgement.

The larva of *E. tripunctaria* was first described in Britain by Harpur-Crewe (1861). It was stated that they are found in damp woods during September feeding on angelica (*Angelica sylvestris*) and hogweed (*Heracleum sphondylium*). The adult was believed to fly in May and June.

The first suspicions of bivoltinism were raised by Harpur-Crewe (1862b and c) who records the capture of a single female on 19.viii.1862 in a locality where autumnal larvae were known to occur. He suggested that this individual represents a second emergence which produces the autumnal larvae and that the spring-flying adults lay their eggs on ". . . some other plant . . ." (i.e. not angelica or hogweed). However, Newman (1869) follows Harpur-Crewe's earlier notes (1861 and 1862a) and states that *E. tripunctaria* is univoltine, flying in May and June.

Tutt (1906) states that larvae are found at the end of May and June and from the end of August to October feeding on umbellifer flowers. He lists angelica, hogweed, cow parsley (*Anthriscus sylvestris*), *Peucedanum* sp., cowbane (*Cicuta virosa*) and *Laserpitium* sp. Further, he states that three broods can be obtained in captivity if fed on elder (*Sambucus nigra*). Adults are recorded in May and June with a second brood in August.

Prout (1907) also states that *E. tripunctaria* is bivoltine and refers to Barrett (1907) and Nickerl (1907) who reared larvae on elder and obtained adults in July of the same year. Barrett (1907) also cites D'Orville (1864) who observed a July emergence from captive larvae fed on cow parsley flowers.

The standard works of Newman & Leeds (1913) and Meyrick (1928) omitted mention of Tutt's (1906), Prout's (1907) and Barrett's (1907) observations and state that *E. tripunctaria* is univoltine. However, South (1939 and subsequent editions) states that unusually early spring emergences can produce a second brood in captivity. He also cites elder and ". . . other Umbelliferae . . ." as foodplants.

Allan (1949) added wild parsnip (*Pastinaca sativa*) and garden chervil to the list of foodplants but does not comment on voltinism.

Prior's (1978) note was merely a request for information regarding larvae resulting from the first brood as none had been found in the wild in Britain at that time.

Simson (1980) states that adults fly in July (i.e. as a second emergence). Although he could not find the first brood larvae they were later stated to feed in July on elder flowers (BENHS, 1981). This was subsequently confirmed by Corley (1984) who found them on elder in June. However, both authors noted that no adults emerged in captivity the same year. All the pupae overwintered and hatched the following May. This led Corley (1984) to believe that some of the spring generation adults laid eggs on yet another plant and that it was these larvae which resulted in the second emergence. He suggested cow parsley as this blooms at the right time of year to support *E. tripunctaria* larvae. McDunnough (1949) cites flowers and seeds of *Viburnum* in North America as larval food sources. Although he does not state which species, both British representatives of this genus, guelder rose (*V. opulus*) and the wayfaring tree (*V. lantana*), also flower at the appropriate time of year for first generation larvae of *E. tripunctaria* (Fitter, Fitter & Blamey, 1974).

As a resumé of the known facts, Skinner (1984) states that adults have been recorded every month between May and September and that larvae feed on elder in July and umbellifers in August and September. He also says that larvae from elder produce adults the following year. However, Corley (1985) found that, of ten larvae collected from elder in late June 1984, three produced second generation adults in late July of the same year.

In his short review, Haggett (1989) erroneously states that D'Orville's (1864) reference to a second generation in captivity remains the only recorded instance (see Corley, 1985). He also states that, in his experience, larvae reared in captivity on cow parsley and elder do not produce a second generation. Further, he suggests that an alternative spring foodplant should be sought (possibly foliage rather than flowers) as searches for larvae on elder flowers in some known *E. tripunctaria* localities, were unsuccessful.

Therefore, our understanding from the literature at this time was that adults emerge in May and June and oviposit on elder and possibly some other plant. The larvae pupate and some of those which had fed on elder emerge in July, August and September, whilst others overwinter and emerge the following May. Those which emerge as a second brood oviposit on various umbellifers and goldenrod (*Soligado virgaurea*) (BENHS, 1981). The resulting larvae pupate and likewise overwinter and produce adults the following May.

Further to these observations the present authors have recorded larvae on hogweed in June and ragwort (*Senicio jacobaea*) in August. The former is interesting as hogweed is a known autumnal foodplant (Harpur-Crewe, 1861). This suggests that it is possible for both broods of *E. tripunctaria* to feed on one plant whereas it has previously been supposed that two are necessary. One of the present authors (G.P.) has also successfully reared captive first generation larvae on flowers of bramble (*Rubus fruticosus*).

Catches of adults in Rothamsted Insect Survey light traps

In order to clarify the known flight periods of this species, data collected from the Rothamsted Insect Survey light traps for the period 1980 to 1987 (during which time all pugs were identified by Riley) were examined.

A total of 457 *E. tripunctaria* individuals were caught over 162 site years at 71 sites throughout Great Britain. Adult moths were caught each month between May and October inclusive. The second brood alone was recorded during 64 site years; the first brood alone during 41 and both broods during 57.

Two separate broods have been recorded at sites throughout England and Wales but in Scotland they have only been caught at Elgin, Morayshire and St Abb's, Berwickshire. However, assumed second brood individuals have been caught during August at many Scottish sites as far north as Fort Augustus, Inverness. At these sites the first generation was absent from the catches.

	May	June	July	August	Sept.	October
Total Number	35	125	32	233	25	7

Table 1. Total numbers of *E. tripunctaria* adults caught in R.I.S. light traps at sites throughout Great Britain from 1980 to 1987.

Two obvious peaks are evident in June (125 individuals) and August (233), from the figures in Table One. This suggests there are two main periods of emergence during the year and the numbers caught support West's (1989) view that the second brood is larger than the first. The two broods can be seen more clearly in Table Two which shows the results from some of the individual sites. They represent 13 years' trapping at four sites and each year at each site shows a definite gap (last column) between the last capture of first brood individuals and the first capture of the second, thus proving the existence of two separate flight periods. This gap is sufficient to allow larvae from the first brood to pupate and produce second generation adults. The figures also show that the second emergence is usually larger than the first.

Conclusions

West (1989) considered that the required proof of bivoltinism in *E. tripunctaria* was captive rearing of second generation adults from larvae collected in spring or early summer. The author may have been unaware of the examples already cited (D'Orville, 1864; Nickerl, 1907; Corley, 1985) as these are documented accounts of this occurrence. Further, both the present authors have reared a great many larvae from elder flowers from several localities in southern England and found that a small percentage produce adults in July and August of the same year. As a criterion for proof of bivoltinism these results must be regarded with caution as captive breeding (as breeders of Lepidoptera know) sometimes produces extra broods when they would not naturally occur. However, in our opinion, alongside the cited results of light trapping, they clearly demonstrate partial bivoltinism in this species.

A major remaining question is how the second emergence (which is only partial) can be larger than the first (which is complete). There are several possible explanations for this including high overwintering pupal mortality and high survival rate of larvae from the first generation due to favourable climatic conditions. Further detailed study would be required to clarify this point.

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			First Brood			Second Brood			
Site no.	*Site name*	*Year*	*Date of first capture*	*Date of last capture*	*Total number caught*	*Date of first capture*	*Date of last capture*	*Total number caught*	*Gap (weeks)*
22	Geescroft I	1984	12.vi	22.vi	3	14.viii	25.viii	5	6½
		1985	4.vi	29.vi	5	17.viii	1.ix	6	7
		1986	9.vi	21.vi	5	11.viii	2.ix	5	7
		1987	29.v	29.v	1	14.viii	17.viii	5	6½
99	Geescroft II	1986	6.vi	16.vi	6	16.viii	1.ix	6	8½
		1987	13.vi	13.vi	1	16.viii	21.viii	4	9
266	Yarner Wood I	1985	12.v	10.vi	2	13.viii	19.ix	3	9
277	Ewingswode	1981	1.vi	4.vi	2	13.viii	27.viii	7	10
		1982	26.v	26.v	1	30.vii	3.viii	3	5
		1983	7.vi	3.vii	3	12.viii	23.viii	9	6
		1984	6.vi	26.vi	4	17.viii	29.viii	4	7
		1986	6.vi	25.vi	5	13.viii	1.ix	3	7
		1987	26.v	21.vi	10	14.viii	6.ix	6	7½

Table 2. Results from four Rothamsted Insect Survey light trap sites operating between 1984 and 1987: Geescroft I and II, Harpenden, Herts. (Site Nos. 22 and 99 resp., O.S. Grid Ref. TL132 128 and TL131 127 resp,); Yarner Wood National Nature Reserve, Devon (Site No. 266, O.S. Grid Ref. SX786 788) and Ewingswode, Monks Wood National Nature Reserve, Cambs (Site No. 277,O.S. Grid Ref. TL200 797).

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